# PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

## PCT

### NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

| | |
|---|---|
| **Date of mailing** (day/month/year)<br>23 June 2000 (23.06.00) | |
| **International application No.**<br>PCT/GB99/03416 | **Applicant's or agent's file reference**<br>A25660 WO |
| **International filing date** (day/month/year)<br>15 October 1999 (15.10.99) | **Priority date** (day/month/year)<br>30 October 1998 (30.10.98) |
| **Applicant**<br>DALBY, David et al | |

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

02 May 2000 (02.05.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

| | |
|---|---|
| **The International Bureau of WIPO**<br>**34, chemin des Colombettes**<br>**1211 Geneva 20, Switzerland** | Authorized officer<br>Juan Cruz |
| Facsimile No.: (41-22) 740.14.35 | Telephone No.: (41-22) 338.83.38 |

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RECD 12 FEB 2001
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# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| Applicant's or agent's file reference | FOR FURTHER ACTION | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) |
|---|---|---|
| A25660 WO | | |
| International application No. | International filing date *(day/month/year)* | Priority date *(day/month/year)* |
| PCT/GB99/03416 | 15/10/1999 | 30/10/1998 |
| International Patent Classification (IPC) or national classification and IPC<br>H04L29/06 | | |
| Applicant<br>BRITISH TELECOMMUNICATION public limited company | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 9 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

| Date of submission of the demand | Date of completion of this report |
|---|---|
| 02/05/2000 | 07.02.2001 |
| Name and mailing address of the international preliminary examining authority:<br>European Patent Office<br>D-80298 Munich<br>Tel. +49 89 2399 - 0 Tx: 523656 epmu d<br>Fax: +49 89 2399 - 4465 | Authorized officer<br>Körbler, G<br>Telephone No. +49 89 2399 8250 |

Form PCT/IPEA/409 (cover sheet) (January 1994)

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/03416

## I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
**Description, pages:**

| | | | | |
|---|---|---|---|---|
| 1,3-14 | as originally filed | | | |
| 2,2a | as received on | 17/11/2000 | with letter of | 13/11/2000 |

**Claims, No.:**

| | |
|---|---|
| 1-8 | as originally filed |

**Drawings, sheets:**

| | |
|---|---|
| 1/6-6/6 | as originally filed |

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   *(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

## V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Yes: | Claims | |
| | No: | Claims | 1,4,5,8 |
| Inventive step (IS) | Yes: | Claims | |
| | No: | Claims | 1-8 |
| Industrial applicability (IA) | Yes: | Claims | 1-8 |
| | No: | Claims | |

2. Citations and explanations
   **see separate sheet**

## VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
**see separate sheet**

Cited documents:

D1: JAU-SHIUNG HUANG ET AL: 'MHTP - A MULTIMEDIA HIGH-SPEED TRANSPORT PROTOCOL' COMMUNICATION FOR GLOBAL USERS, ORLANDO, DEC. 6 - 9, 1992, vol. 3, 6 December 1992 (1992-12-06), pages 1364-1368, XP000390432 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

D2: EP-A-0 725 506

D3: FR-A-2 736 486

D4: DELGROSSI L ET AL: 'HEITP - A TRANSPORT PROTOCOL FOR ST-II' COMMUNICATION FOR GLOBAL USERS, ORLANDO, DEC. 6 - 9, 1992, vol. 3, 6 December 1992 (1992-12-06), pages 1369-1373, XP000390433 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

The following documents were not cited in the international search report.

D5: WILSON D., GHANBARI M.: 'AN EFFICIENT LOSS PRIORITY SCHEME FOR MPEG-2 VARIABLE BIT RATE VIDEO FOR ATM NETWORKS', IEEE 1996, Essex University

D6: RFC 1693: 'AN EXTENSION TO TCP : PARTIAL ORDER SERVICE', November 1994

**Re Item V**

**Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1a. The present formulation of independent apparatus claim 1 is such that its corresponding subject-matter is not novel having regard to the disclosure of document D5.

D5 discloses (the references in parentheses applying to this document):

A data streaming apparatus (Figure 4), having:

a data input (Video in) for receiving data frames (Anchor frames, B frames) encoded by a layered encoding algorithm (MPEG2-Encoder and page 1956, right-handed column, line 25-31: "Otherwise, for applications...");
packetising means to insert received data frames, so encoded, into one or more predetermined packet structures, the data frames associated with each encoded layer being inserted into a different respective sequence of packets (Anchor stream, B stream);
packet numbering means to assign a data sequence number to each packet generated by the packetising means, the data sequence number assigned to a packet being indicative of the order of receipt, at the data input, of encoded data inserted with the packet; and
a network interface to transmit, in use, packets so created (page 1956, left-handed column, line 18-22: "The MPEG-2 encoder takes the input and re-orders the sequence so that B frames...".

This is the wording of claim 1 of the present application, the subject-matter of which is consequently not novel. The claim therefore does not meet the requirements of Art. 33(2) PCT.

The same objection could have been raised starting from document D1 as the document discloses the same technical features in the form of a protocol.

1b. The subject-matter of client apparatus claim 4 corresponds in terms of essential features to that of data streaming apparatus claim 1, because merely corresponding to the **symmetrical (encoding - decoding)** function of the data streaming apparatus at the other side of the line.
Therefore, the objection raised above applies equally to claim 4 which does consequently not meet the requirements of Article 33(2) PCT for lack of novelty.

The same objection could have been raised starting from document D1.

1c. It should be noted that even if novelty of claims 1 and 4 could be argued based on minor differences between the features of cited claims and those disclosed in D5, the subject-matter of claims 1 and 4 would still not involve an inventive step, Article 33(3) PCT, having regard to the disclosure of D5 especially as this

document discloses the same object and the same type of solution as claimed in these claims.

2. Independent method claim 5, although phrased as a method claim, is nonetheless a simple repetition of the subject-matter of apparatus claim 1 and hence does not meet the requirements of the PCT for the same reasons.

3a. The present formulation of independent method claim 8 is such that its corresponding subject-matter is not novel having regard to the disclosure of document D6.

D6 discloses (the references in parentheses applying to this document):
A method of ordering data packets within one or more separately accessible sequences of data packets received over a communication network **(page 2, line 7-12: "The idea of a partial order service..." and page 3, line 1-12: " Current applications that need to communicate...")**, each sequence of data packets conveying data frames relating to a different layer of encoded data frames output by a layered encoding algorithm, each data packet having assigned thereto a data sequence number indicative of the order of output of encoded data, conveyed by said data packet, from said encoding algorithm, and a further sequence number indicative of the position of said data packet within the respective sequence of data packets, the method comprising selecting data packets in order of receipt within a first of said accessible sequences of data packets, outputting selected packets from said first sequence in order of assigned data sequence number and, upon selecting a packet from said first sequence having an out-of-sequence data sequence number **(page 3, line 15-25: "...One motivating application for a partial order service..." and Figure 3 and page 8-9: section 2.2 Example 2: Multimedia , the whole section)**, using the further sequence number assigned to said selected packet to determine whether the next expected packet, according to the data sequence number, is associated with other than said first sequence of data packets **(page 25, line 18-21: "When an object arrives, the question is no longer, "is this the next deliverable object ?", but rather, "is this ONE OF the next deliverable objects ?...")**.

This is the wording of claim 8 of the present application, the subject-matter of which is consequently not novel. The claim therefore does not meet the requirements of Art. 33(2) PCT.

3b. It should be noted that even if novelty of claim 8 could be argued based on minor differences between the features of cited claim and those disclosed in D6, the subject-matter of claim 8 would still not involve an inventive step, Article 33(3) PCT, having regard to the disclosure of D6 especially as this document discloses the same object and the same type of solution as claimed in this claim.

4. The dependent claims 2-3, 6-7 do not seem to contain any subject-matter which, in combination with the subject-matter of the claim on which they are dependent, would lead to a claim involving an inventive activity (Article 33(3) PCT).
They are either derivable from the above cited documents or concern simple embodiments without inventive merit in themselves.

5. In his reply to the written opinion the Applicant asserts that:

5a. "D5 discloses nothing more than a layered encoding algorithm for use with a modified MPEG-2 encoder, one of a number of possible layered encoding algorithms, for generating a sequence of "data frames encoded by a layered encoding algorithm" that might form an input to the apparatus of claim 1."
However, the layered encoding algorithm for use with a modified MPEG-2 encoder might form an input to the apparatus claim 1.
The Applicant itself admits that this feature of D5 falls into the scope of claim 1.

5b. Further the Applicant asserts that:
"Any sequence numbering disclosed in D5 relates to frame ordering within the MPEG-2 encoder, **prior** to encoding, ensuring that the display order of input video frames may be reproduced by a decoder after decoding a received sequence of encoded I/P and B frames".
However, Document D5 discloses that anchor frames and B frames will be partioned **after** encoding (page 1956, left-hand column, line 29-31).

5c. Furthermore the Applicant asserts that:
"D5 does not disclose writing frame sequence numbers into frames...".
However, D5 discloses (page 1956, left-hand column, line 9-17 and Figure 3) a method named frame sequence partitioning (FSP). The encoder, transmission and decoder discloses frame sequences at and around the $n^{th}$ frame of an input sequence, where n represents the chronological presentation or display order. Therefore each frame gets a sequence ordering number.

5d. Furthermore the Applicant asserts that:
"...Claim 8 requires two sequence numbers..." and "...D6 does not disclose such cross-layer sequence numbers...".
D6 describes (page 9, Figure 3 and line 3-8): "...Of particular interest to our discussion of partial ordering is the fact that , while objects of a given media type generally must be received in order, there exist flexibility between the separate "streams" of multimedia data (where a "stream" represents the sequence of objects for a specific media type)." and (page 25, section 4.2.2) "When an object arrives, the question is no longer, "is this the next deliverable object?", but rather, "is this ONE OF the next deliverable objects?" Hence, it is convenient to think of a "Deliverable Set" of objects with a partial order protocol."
However, it is implicit that a partial order sequence within a global order sequence has to have a first global sequence number, representing the global sequence ordering number, and a second sequence ordering number, representing a partial sequence ordering number.
Moreover, Document D6 describes that the question is not longer "what comes next" referring to the global sequence ordering number, but rather "which is one of the next partial sequence number ?" (**cross-referencing** to different partial sequence ordering sets (layers)).

These arguments are therefore considered as not convincing.

**Re Item VII**

**Certain defects in the international application**

1. Reference signs in parentheses should be inserted in the claims to increase their intelligibility, Rule 6.2(b) PCT. This applies to both the preamble and characterising portion.

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# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference | **FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below. | |
|---|---|---|
| A25660 WO | | |
| International application No. | International filing date *(day/month/year)* | (Earliest) Priority Date *(day/month/year)* |
| PCT/GB 99/03416 | 15/10/1999 | 30/10/1998 |
| Applicant | | |
| BRITISH TELECOMMUNICATION public limited company | | |

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [X] as suggested by the applicant.

   [ ] None of the figures.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03416

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | JAU-SHIUNG HUANG ET AL: "MHTP - A MULTIMEDIA HIGH-SPEED TRANSPORT PROTOCOL" COMMUNICATION FOR GLOBAL USERS, ORLANDO, DEC. 6 - 9, 1992, vol. 3, 6 December 1992 (1992-12-06), pages 1364-1368, XP000390432 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS | 1,2,4-8 |
| A | page 1364, left-hand column, line 12 -page 1366, left-hand column, line 36 page 1368, left-hand column, line 3 - line 47 | 3 |
| | --- -/-- | |

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 14 February 2000 | 24/02/2000 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016 | RAMIREZ DE AREL.., F |

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Form PCT/ISA/210 (second sheet) (July 1992)

International Application No
PCT/GB 99/03416

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication,where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | DELGROSSI L ET AL: "HEITP - A TRANSPORT PROTOCOL FOR ST-II" COMMUNICATION FOR GLOBAL USERS, ORLANDO, DEC. 6 - 9, 1992, vol. 3, 6 December 1992 (1992-12-06), pages 1369-1373, XP000390433 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS page 1371, left-hand column, line 2 - line 24 --- | 4,7,8 |
| A | EP 0 725 506 A (IBM) 7 August 1996 (1996-08-07) page 4, line 4 -page 5, line 4 --- | 1-8 |
| A | FR 2 736 486 A (PY STEPHANE) 10 January 1997 (1997-01-10) page 4, line 31 -page 7, line 24 ----- | 1-8 |

1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/03416

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| EP 0725506 A | 07-08-1996 | US 5533021 A | 02-07-1996 |
| | | JP 2898914 B | 02-06-1999 |
| | | JP 8321836 A | 03-12-1996 |
| | | JP 11261600 A | 24-09-1999 |
| | | US 5537408 A | 16-07-1996 |
| | | US 5652749 A | 29-07-1997 |
| FR 2736486 A | 10-01-1997 | NONE | |

*FOR THE PURPOSES OF INFORMATION ONLY*

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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# DATA TRANSPORT

This invention relates to transport of data over communications networks and, in particular, to transport of data encoded by layered encoding algorithms.

Networks based upon the Internet Protocol (IP) are being used increasingly to convey multi-media data transmissions, enabled by the use of compression algorithms to reduce data volumes to sufficiently low levels for transport over relatively low data rate network connections. However, problems remain to be overcome to achieve distribution of multi-media services, audiovisual services for example, to a large number of client terminals having a variety of different capabilities for receipt of such services. In particular, some clients may have access only to limited data rate network connections enabling receipt of only low-resolution and low picture rate video. Other users may be connected to relatively high bandwidth corporate LANs and demand higher quality reception. Known methods for providing different levels of service to different users include point-to-point services whereby a tailored version of a session is separately transmitted directly to each user at their network address, and "simulcast" techniques whereby a number of different data rate transmissions are broadcast and users may select and share that most suited to their needs. However, both point-to-point and simulcast techniques involve significant overlap and duplication of data between transmitted data streams and are clearly inefficient in their consumption of network capacity.

Layered encoding techniques, such as that implemented for example under the H.263 standard for video data compression, defined in "Video Coding for Low Bit Rate Communications", International Telecommunication Union (ITU) - T Recommendation H.263, January 1998, enable data representing different resolutions of video to be encoded as separate layers of data frames. At the lowest layer, layer 0, a "lowest common denominator" encoding may be provided. Frames within layer 0 may provide a relatively low resolution representation of original images, not necessarily all the original images. Data frames in higher layers may add increasing levels of detail to representations by lower layer frames or may encode images omitted from the lower layers altogether. Each layer of encoded data frames may be broadcast separately by a server, each layer to a different multi-casting network address. It is intended that most user equipment may be

able to receive the lowest layer 0 by accessing the appropriate multi-cast address for layer 0. Users who so choose, or who have equipment capability to receive higher layers may access one or more of the corresponding network addresses to enjoy a higher quality of audiovisual service. In this way, disparate client needs may be satisfied by a single broadcast of each layer without unnecessary duplication of data.

Where multi-casting techniques are being used in relation to IP networks, a currently preferred protocol for transporting layers of encoded data frames is the User Datagram Protocol (UDP) as defined in "User Datagram Protocol", Internet RFC 768, J. Postel, August 1980, published on the Internet by the Internet Engineering Task Force (IETF). However, while UDP offers a more rapid procedure for sending messages with a minimum of protocol mechanism, in comparison with the Transmission Control Protocol (TCP) for example, this is achieved at the expense of guaranteed delivery. Data may be lost, perhaps to the extent that a one layer may be lost during conveyance over a network, or at least delayed with respect to other layers. Therefore, besides exercising a choice not to receive a higher layer of encoded data, there are involuntary reasons why a client apparatus may not receive all encoded data broadcast within a session. In both circumstances, problems may arise at a client apparatus in presenting received data to a decoder in the correct order for decoding.

According to a first aspect of the present invention, there is provided a data streaming apparatus, having:

a data input for receiving data frames encoded by a layered encoding algorithm;

packetising means to insert received data frames, so encoded, into one or more predetermined packet structures, the data frames associated with each encoded layer being inserted into a different respective sequence of packets;

packet numbering means to assign a data sequence number to each packet generated by the packetising means, the data sequence number assigned to a packet being indicative of the order of receipt, at the data input, of encoded data inserted within the packet; and

a network interface to transmit, in use, packets so created.

The present invention enables a sequence number to be assigned to each data packet, conveying encoded data, representative of the correct order for

subsequent presentation of the encoded data to a decoder. Such a sequence number enables packets received at a client apparatus to be correctly ordered, even when the client apparatus does not receive all the transmitted layers of packets or when individual packets are lost. This is particularly important where differential encoding algorithms are used, such as that defined by the H.263 standard.

Differential encoders, such as those implementing H.263, generate layered data streams each having a highly variable data rate. The quantity of data required to encode each of a sequence of images differs according to the degree of variation between successive images. In general, the order of output of encoded frames by an encoder is the order required for input to a decoder. However, if during transport from encoder to decoder, one layer is lost or delayed significantly with respect to another, or if particular packets are lost, problems arise at the receiving equipment in presenting the received data packets to a decoder in the correct order for decoding. Therefore, while use of multi-layered encoding appears to solve the problem of accommodating different client needs, new problems arise in decoding multi-layered transmissions.

Preferably, a further sequence number may be assigned to each packet representing the order of transmission of the packet, under the control of a selected protocol, within a sequence of packets conveying a particular layer of encoded data frames. Such a sequence number may be used to improve packet ordering efficiency through identifying whether all packets expected within a particular packet sequence have been received and that the next packet for decode must lies in another packet sequence.

According to a second aspect of the present invention, there is provided a client apparatus having:

a network interface;

packet receiving means to receive one or more sequences of data packets from the network interface, each data packet having a predetermined packet structure, each of said one or more sequences of data packets conveying a different respective layer of encoded data frames generated by a layered encoding algorithm and each data packet having assigned thereto a data sequence number indicative of the order of output of encoded data, conveyed by the data packet, from said layered encoding algorithm;

packet ordering means to place said received data packets into a decoding order using said data sequence numbers; and

output means to output packets so ordered.

According to a third aspect of the present invention, there is provided method of generating data packets to convey data frames encoded by a layered encoding algorithm for transmission over a communications network, each layer of encoded data frames being conveyed by a different respective sequence of data packets, including the steps of:

(1) receiving an encoded data frame;

(2) inserting data from said data frame into one or more data packets generated according to a predetermined packet structure;

(3) assigning, in respect of one of said one or more data packets, a data sequence number indicative of the order of receipt of encoded data inserted into said packet;

(4) writing said data sequence number at a predetermined position within said packet; and

(5) performing steps (3) and (4) in respect of each of said one or more data packets generated at step (2).

According to a fourth aspect of the present invention, there is provided method of ordering data packets received within one or more separately accessible sequences of data packets generated according to the method of Claim 5, including the steps of:

(1) receiving one or more data packets on one or more of said one or more separately accessible sequences of data packets;

(2) selecting, from those data packets received at step (1), that data packet having the smallest assigned data sequence number amongst non-selected data packets;

(3) outputting said selected data packet;

(4) repeating steps (1) to (3).

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings of which:

Figure 1 shows a video streaming apparatus according to preferred embodiments of the present invention;

Figure 2 shows a client apparatus arranged to receive signals transmitted by the apparatus of Figure 1;

Figure 3 shows a typical hierarchy of layered data frames, encoded from a small sequence of video images, for transmission by the apparatus of Figure 1;

Figure 4 shows the result of applying a packet numbering algorithm, according to preferred embodiments of the present invention, to packets generated to convey encoded data frames shown in Figure 3;

Figure 5 shows the structure of a packet header according to the Real-time Transport Protocol (RTP) as used in a preferred embodiment of the present invention; and

Figure 6 is a flow diagram showing steps in the operation of a preferred client apparatus, relating in particular to the ordering of packets broadcast by the apparatus of Figure 1.

Preferred embodiments of the present invention will be now be described in the particular context of a video streaming apparatus, although the present invention may be applied to other forms of data broadcast and receiving apparatus, not necessarily in a client-server arrangement, involved in a single or multi-media session with data encoded by layered encoding techniques.

Referring to Figure 1, a video streaming apparatus 100 is shown, according to preferred embodiments of the present invention, for use in broadcasting multi-layer encoded audiovisual data from an encoded audio/video data source 105 to client systems over a communications network 110. The audio/video data source 105 may for example be a database of encoded video data for use in a "video-on-demand" system, or it may be a multi-layer encoded real-time audiovisual data stream to be transmitted as a live broadcast. The video streaming apparatus 100 accepts layers of encoded data from the source 105 at an input 115 before passing them to a packetiser 120. The packetiser 120 may implement a known algorithm for separately incorporating data from each layer of encoded data into a different respective stream of packets according to one or more predetermined packet structures. For example, one or more layers may be incorporated into packets having a structure defined for use with the Real-Time Transport Protocol (RTP), described by Internet Request for Comment (RFC) 1889, January 1996 – "RTP: A Transport Protocol for Real-Time Applications" by H.Schulzrinne, S.Casner, R.Frederick and V.Jacobson, and published on the

Internet by the Internet Engineering Task Force (IETF). Once arranged according to their respective predetermined packet structure, the layers of packets are passed to a packet numbering module 125 to be numbered by a packet numbering method according to preferred embodiments of the present invention. The numbered packets are then passed to instances of a session handler 130, one instance of session handler per layer of packets. Each instance of session handler 130 may implement an appropriate protocol to control transfer of the respective layer of packets over the communications network 110, via a network interface 135, to one or more predetermined network addresses, multi-cast addresses for example. Protocols operating at lower levels in a protocol hierarchy of may be implemented by the network interface 135 as appropriate to the communications network 110. For example, at the level below RTP, the User Datagram Protocol (UDP) referenced above may be implemented by the network interface 135 to operate in conjunction with the Internet Protocol (IP).

Preferably, for simplicity, all layers of encoded data may be broadcast under the control, at the session level at least, of respective instances of the same protocol using the same packet structure. However, the scope of the present invention is intended to encompass those situations in which more than one type of protocol is employed to broadcast layers of encoded data received at the input 115.

Referring to Figure 2, a typical client apparatus 200 is shown for use in receiving, over the communications network 110, audio and/or video broadcasts by one or more sources having features in common with the video streaming apparatus 100 of Figure 1. The client apparatus 200 may create instances of a session handler 210, each instance of session handler 210 "listening" for data received at a particular network address, one instance corresponding to each layer of packets received over the network via a network interface 205. The received layers of packets pass from their respective session handlers 210 into a source demultiplexer 215. In the event that multiple video streamers or other types of source are broadcasting on the same session, each source may preferably be separately identifiable by the source demultiplexer 215 using information inserted into packet headers by the respective source streamer. For each distinct source identified, the source demultiplexer may create one instance of a blender 220, collating all packets received via the session handlers 210 carrying the same

source identifier, and passing the collated packets to the blender 220. The blender 220 may implement an algorithm, according to preferred embodiments of the present invention, for ordering packets received from the particular source using packet numbering information inserted by the packet numbering module 125 of the respective source, video streamer 100 for example. Having established the correct packet order, taking account of any missing or inaccessible layers and packets, the blender 220 may pass the ordered packets to a depacketiser 225 to recover the layers of encoded data from the respective predetermined packet structure used by the particular streaming source, by packetiser 120 in the case of a video streamer 100. The depacketiser 225 passes the recovered encoded data, now in the correct sequence for decoding, to an output 230. The ordered data output from the client apparatus 200 may be taken by an appropriate decoder and, following decoding, reproduced at a display and/or audio output apparatus as appropriate.

Referring to Figure 3, a typical hierarchy of layered data frames is shown, encoded from a small sequence of video images, as might be presented to the input 115 of a video streamer 100. The encoded frames 340 are shown arranged as three layers, 300, 305 and 310 corresponding to a lowest layer, a middle layer and a top layer respectively. Further layers may be generated according to the particular encoding algorithm implemented by the source 105. Each encoded frame 340 of Figure 3 is shown with a number in the range 1 to 10, indicating the order of output by the encoded data source 105 and hence the required order for subsequent presentation of the frames to a decoder. The frames 340 in Figure 3 are shown grouped within five columns, each column of frames being encoded to represent a respective original image 315-335. For example, original image "A" 315, is shown encoded as a frame number "1" in the lowest layer 300, a frame "2" in middle layer 305 and a frame "3" in the top layer 310. Original image "B" 320 is represented only in the top layer 310 by a frame generated with number "4". The original image data 315-335 would not normally be presented to the input 115 of a video streaming apparatus 100.

The sequence of encoded frames 1-10 of Figure 3 may, for example, be generated according to a video encoding algorithm such as H.263, referenced above. If the H.263 encoding technique is used to encode the images 315-335 of Figure 3, each frame 340 in the lowest layer 300 may represent a low-resolution version of the respective original image and may be encoded using the basic H.263

algorithm at QCIF resolution as described in Section 4.1 of the referenced specification. Frames in layers 305 and 310 represent increasingly detailed enhancements to the low-resolution image represented by the respective frame in layer 300. Under H.263, the middle and top layers may be encoded according to the definition in Annex O, "Temporal, SNR and Spatial Scalability Mode", of the above-referenced H.263 specification.

Not all original images may be represented in the lower layers 300, 305. In the particular sequence shown in Figure 3, only every fourth original image is represented in the lowest layer 300 and every second original image in the middle layer 305. Thus, a client apparatus able or choosing to decode only the lowest layer of frames will display a representation of the original sequence of images having a relatively low resolution and a relatively low image rate as compared with client apparatus able or choosing to decode both the lowest and middle layers. Apparatus able to receive and decode all three broadcast layers 300-310 will be able to display all the original images (315-335) at the highest resolution available. It is intended that a lower data rate network connection may be used to receive data frames at the lowest layer, making that layer accessible to most client equipment.

Referring to Figure 4, a diagram is provided to show a typical breakdown of those encoded frames 340, representing the first three original images 315, 320 and 325 of Figure 3, across corresponding layered sequences of packets 400 by the packetiser 120. Figure 4 also shows the result of applying a packet numbering scheme to those packets as may be implemented by the packet numbering module 125 according to preferred embodiments of the present invention. A typical packetiser 120 may operate to packetise each layer of encoded frames separately, generating, as in the present example, three separate streams of packets, one stream for each layer. As discussed in relation to Figure 1 above, the packetiser 120 may be arranged to implement one or more packet structures appropriate to the particular protocol chosen at the session level to control the conveyance of each encoded layer of data. Preferably, each layer of encoded data may be conveyed over a network using a different respective instance of the Real-time Transport Protocol (RTP) referenced above. The packetiser 120 would, in that case, split the data within a layer of encoded frames 340 across the payload portions of a sequence of RTP packets, according to the RTP packet structure

definition. Conveniently, if packetising data encoded using the H.263 algorithm referenced above, a specific definition of an H.263 payload header is available for inclusion in RTP packets, as defined in "RTP Payload Format for H.263 Video Streams", Internet RFC 2190, September 1997, published on the Internet by the IETF. Alternative and equally satisfactory session-level protocols may be selected for implementation by the packetiser 120, employing their own respective packet structures to convey the encoded layers 300-310 of data frames 340.

Referring to Figure 4, as indicated above, each of the packets 400 is shown labelled with sequence numbers applied by packet numbering module 125. A preferred method of numbering involves the assignment of two sequence numbers to each packet 400. The number shown in the upper half of each packet 400 of Figure 4 may be referred to as a "layer sequence number" LSEQ, while the number shown in the lower half of each packet may be referred to as a "cross-layer sequence number" XSEQ. The sequence of LSEQ numbers indicates the order of transmission of packets within one specific layer. The XSEQ numbers are intended to represent the correct overall order for presentation of encoded data conveyed by those packets to a decoder 225 at a client apparatus 200. The XSEQ sequence reflects, in particular, the order that encoded data frames emerged from the source 105.

Protocols such as RTP provide a facility to assign sequence numbers to packets within a particular RTP packet stream. In this case, each layer of encoded data may be broadcast as a separate RTP packet stream under the control of different RTP session. Hence, within one layer, the respective (RTP) session handler 130 may automatically assign a layer sequence number LSEQ to each packet before transmission and write the sequence number at a predetermined position with the packet. Other types of protocol may not provide such a facility for assignment of layer sequence numbers. Hence the packet numbering module 125 may implement both layer sequence number assignment and cross-layer sequence number assignment if required.

With different layers being typically broadcast under the control of separate protocol sessions, as with RTP, there is no overall mechanism for assigning XSEQ numbers across layers. In order to assign a sequence of XSEQ numbers in particular, the packet numbering module 125 may be provided at a point immediately following the packetiser 120 and immediately before the

individual packet streams go to their respective session handlers 130 for broadcast. If required, the packet numbering module 125 may retain access to information on the order of receipt of encoded data frames at the input 115 in order to correctly assign XSEQ numbers to packets emerging from the packetiser 120. It is particularly important, when encoding data using a differential encoding algorithm such as that defined by H.263, to subsequently decode those data in the correct sequence. Assignment of an XSEQ number by the packet numbering module 125 provides a particularly convenient method of recording the correct data sequence at the packet level. Data loss or reordering of data typically occurs at the packet level. As will be discussed in the following, recording of a layer sequence number LSEQ and, in particular, a cross-layer sequence number XSEQ enables a client apparatus 200, according to preferred embodiments of the present invention, to re-order packets received out of sequence and to take account of missing packets and missing or inaccessible encoded data layers.

Referring to Figure 5, the packet header structure defined for use under RTP is shown. The RTP packet structure may be used by preferred embodiments of the present invention to record packet sequence numbers. Figure 5a shows the RTP header structure, including an optional RTP Header Extension, while Figure 5b shows the structure of the header extension itself, all details of which are described by the above-referenced RTP definition document. The RTP packet header of Figure 5a includes a Sequence Number field occupying the third and fourth octets. This field is used within the RTP protocol to record the transmission order of packets within the particular packet stream and may therefore perform the role of the layer sequence number LSEQ.

To accommodate the cross-layer sequence number XSEQ, the packet numbering module 125 may preferably use the optional RTP header extension, shown in Figure 5a at a position immediately following the "Contributing Source (CSRC) Identifiers". With this intention, the packetiser 120 may set the extension bit "X" - bit 4 of the RTP header – and include one RTP Packet Header extension, having the structure shown in Figure 5b, within each generated packet. Within each packet, the packetiser 120 may record a unique profile-specific identifier within the "profile" field of the header extension and may set the "length" field to 1, including one 32 bit "header extension" field. Such an extension field length should be adequate for use in recording XSEQ numbers generated within a typical

multi-media session. The packet numbering module 125 may then write an appropriate XSEQ number into the extension field of each packet received from the packetiser 120.

While the RTP packet structure includes fields suitable for recording assigned sequence numbers, other protocols and packet structures may not provide predetermined positions within their packets to carry sequence number information. If necessary, one or more further packet data streams may need to be generated by the packetiser 120, to be transmitted approximately in synchronisation with other packet streams, to convey sequence numbering information assigned by the packet numbering module 125 and linked, for example by a packet identifier, to packets carrying encoded data. On receipt of the "sequence number packet stream", a client apparatus may extract and use the sequence numbering information in much the same way as described below.

As discussed above in relation to the identification of a transmitting source by the source demultiplexer 215 of a client apparatus 200, for example where multiple video streamers 100 are transmitting RTP packets over the communications network 110, the "SSRC" field in the RTP header of Figure 5a may be used by an RTP session handler 130 to record within each RTP packet an identifier for the particular video streamer 100 generating the packet. The source demultiplexer 215 of a client apparatus 200 may then read the SSRC field in received packets to distinguish between packets from one video streamer and another.

Referring to Figure 6, a flow diagram is provided to show a sequence of steps in operation of an instance of a blender 220 relating to the ordering of packets, received from a particular streamer 100, numbered by a packet numbering module 125, according to preferred embodiments of the present invention. Preferably, a variable "TOP_LAYER" may be set at a predetermined value in a particular client apparatus 200, to record the highest numbered layer that the particular apparatus is set to receive and decode, either by choice or as limited by equipment capability or network connection bandwidth. The TOP_LAYER value may be set within the range 0 to n, where n is the highest numbered layer transmitted by data streaming sources accessible over the network 110.

Referring to Figure 6, processing by the blender 220 may be seen to begin at STEP 600. At STEP 602, a pre-processing step is performed on packets already

received to place them into layer sequence number (LSEQ) order within their respective layer. Ordering of packets by LSEQ number may be implemented by a known and simple ordering algorithm and, as such, further detail of STEP 602 will not be discussed in this specification.

At STEP 605, the blender 220 reads the first received packet on layer 0 (PKT[0]) and uses the layer sequence number (LSEQ) and cross-layer sequence number (XSEQ) contained in that packet to initialise counters LPROG[] and XPROG respectively for use in determining the next expected number in each of the packet numbering sequences. At STEP 610, variables are initialised ready for processing packets from the currently selected layer, layer 0 initially. At STEP 615, an attempt is made to read the packet having the lowest layer sequence number (LSEQ) from the layer (L) currently being processed (initially layer L=0). Packets already received in time for operation of STEP 602 will have been ordered by layer sequence number so that, among those already received, the next packet read from the layer L may be assumed to have the lowest LSEQ number. If, at STEP 620, a packet is available in layer L, then, at STEP 625, the cross-layer sequence number (XSEQ) in that packet is compared with the next expected cross-layer sequence number. If, at STEP 625, the current packet is the next in the cross-layer sequence then, at STEP 660, the current packet sequence numbers are used to set the XPROG and LPROG[L] counter variables before, at STEP 665, that packet is forwarded to the decoder 225.

If, at STEP 620, no packet is available on the current layer, then at STEP 675 a flag is set to indicate that packets are unavailable on a layer and processing proceeds to STEP 640 to enable higher layers to be accessed in search of packets.

If, at STEP 625, the current packet is not the next in the cross-layer sequence, then either the next expected packet is missing from within the current layer or it lies in another layer. A following sequence of steps attempts to establish whether the next expected packet for decoding is currently missing – possibly delayed - within the current layer, or whether it may be found in another accessible layer. Therefore, at STEP 630, the blender 220 first checks whether the current packet is the next expected packet within the current layer (L). If not, then at STEP 670 a flag is set to indicate that the current packet is out of sequence in its layer before processing continues to STEP 635. If, at STEP 630, the current packet was the next expected packet in its layer, then the packet having the next

expected XSEQ number must lie in another layer. However, in case the packet is soon found not to lie in a layer accessible by the client apparatus 200, or to be otherwise lost (from STEP 670), then at STEP 635 a variable recording the smallest recently encountered XSEQ number is updated along with the layer in which that respective packet was found. This will be the point of continuation in processing if the packet with the next expected XSEQ number it not located in any of the accessible layers. But first, any other accessible layers are checked.

The layer number is incremented at STEP 640. If the new current layer is at or below the highest layer accessible to the client apparatus at STEP 645, then processing returns to STEP 615 and the next expected packet is sought within that layer as described above. However, if at STEP 645, the new current layer is inaccessible then, at STEP 650, a check is made to determine whether packets are currently unavailable on any layer. If, at STEP 650, one or more layers have no received packets available, then processing restarts at STEP 610, looking again for the next expected packet, beginning at layer 0. If, at STEP 650, all layers have at least one packet available, then at STEP 652 it is determined whether or not the current packet is the next expected packet within its layer. If, at STEP 652 the current packet is correctly ordered within its layer, then the next expected packet in the XSEQ order must lie in a higher layer, one that is not accessible to the particular client apparatus 200. Therefore, the best that can be achieved is to select the packet with lowest XSEQ number on any layer. Therefore, at STEP 655, the layer having the packet with the lowest XSEQ number is selected as the new current layer, and that selected packet is treated as the next available packet for decoding. The XPROG and LPROG[L] sequence number counters are reset to the current packet values at STEP 660 and the selected packet is sent for decoding at STEP 665.

If, at STEP 652, the current packet was out of sequence within its layer, then at STEP 680, the blender 220 may optionally elect to wait for the next one or two packets to arrive on that layer for example, in case the next expected packet within the layer arrives (in which case processing would restart at STEP 610) or to continue without further delay to STEP 685 and select the layer having the packet with the lowest XSEQ number as the new current layer, and select that packet as the next available packet for decoding, proceeding to STEP 660.

After sending a packet for decoding at STEP 665, processing returns to step 610, resetting variables related to out-of-sequence processing and resetting the layer number L to 0, before continuing as described above.

It will be clear that more sophisticated processing steps may be included to implement different strategies in the event that, at STEP 652, received packets within a layer are out of sequence within that layer. If the nature of the communications network 110, or the protocols selected to transfer packets across it, are such that individual packets may be delayed within a layer, then it may be beneficial to implement more sophisticated waiting algorithms if there is a possibility that the expected packet may arrive later. Such a strategy is suggested in STEP 680 of Figure 6 without going into detail. Alternatively, with pure audio data for example, the effect of a lost packet may be partially overcome by inserting a duplicate of the immediately preceding packet, rather than leave a gap or risk further delay. An equivalent strategy may be available with encoded video data, if manageable under the selected encoding/decoding algorithm.

Preferably, a more sophisticated algorithm may be implemented to merge the ordering of received data packets within a layer with processing steps indicated within Figure 6 from STEP 605 onwards, rather than perform pre-processing to order received data packets by LSEQ number within each layer.

CLAIMS

1. A data streaming apparatus, having:

a data input for receiving data frames encoded by a layered encoding algorithm;

packetising means to insert received data frames, so encoded, into one or more predetermined packet structures, the data frames associated with each encoded layer being inserted into a different respective sequence of packets;

packet numbering means to assign a data sequence number to each packet generated by the packetising means, the data sequence number assigned to a packet being indicative of the order of receipt, at the data input, of encoded data inserted within the packet; and

a network interface to transmit, in use, packets so created.

2 A data streaming apparatus according to Claim 1, wherein the packet numbering means are arranged to assign a further sequence number to each packet generated by the packetising means, said further sequence number being indicative of the position of the packet within the respective sequence of packets.

3. A data streaming apparatus according to Claim 1, wherein the packetising means are arranged to generate one or more further sequences of packets for use in conveying data sequence numbers assigned by the packet numbering means.

4. A client apparatus having:

a network interface;

packet receiving means to receive one or more sequences of data packets from the network interface, each data packet having a predetermined packet structure, each of said one or more sequences of data packets conveying a different respective layer of encoded data frames generated by a layered encoding algorithm and each data packet having assigned thereto a data sequence number indicative of the order of output of encoded data, conveyed by the data packet, from said layered encoding algorithm;

packet ordering means to place said received data packets into a decoding order using said data sequence numbers; and

output means to output packets so ordered.

5. A method of generating data packets to convey data frames encoded by a layered encoding algorithm for transmission over a communications network, each layer of encoded data frames being conveyed by a different respective sequence of data packets, including the steps of:

(1) receiving an encoded data frame;

(2) inserting data from said data frame into one or more data packets generated according to a predetermined packet structure;

(3) assigning, in respect of one of said one or more data packets, a data sequence number indicative of the order of receipt of encoded data inserted into said packet;

(4) writing said data sequence number at a predetermined position within said packet; and

(5) performing steps (3) and (4) in respect of each of said one or more data packets generated at step (2).

6. A method of generating data packets according to Claim 5, wherein step (3) includes assigning a further sequence number to said one of said one or more data packets indicative of the order of transmission of said data packet within a respective sequence of packets, and wherein step (4) includes writing said further sequence number at a further predetermined position within said data packet.

7. A method of ordering data packets received within one or more separately accessible sequences of data packets generated according to the method of Claim 5, including the steps of:

(1) receiving one or more data packets on one or more of said one or more separately accessible sequences of data packets;

(2) selecting, from those data packets received at step (1), that data packet having the smallest assigned data sequence number amongst non-selected data packets;

(3) outputting said selected data packet;

(4) repeating steps (1) to (3).

8. A method of ordering data packets within one or more separately accessible sequences of data packets received over a communications network, each sequence of data packets conveying data frames relating to a different layer of encoded data frames output by a layered encoding algorithm, each data packet having assigned thereto a data sequence number indicative of the order of output of encoded data, conveyed by said data packet, from said encoding algorithm, and a further sequence number indicative of the position of said data packet within the respective sequence of data packets, the method comprising selecting data packets in order of receipt within a first of said accessible sequences of data packets, outputting selected packets from said first sequence in order of assigned data sequence number and, upon selecting a packet from said first sequence having an out-of-sequence data sequence number, using the further sequence number assigned to said selected packet to determine whether the next expected packet, according to data sequence number, is associated with other than said first sequence of data packets.

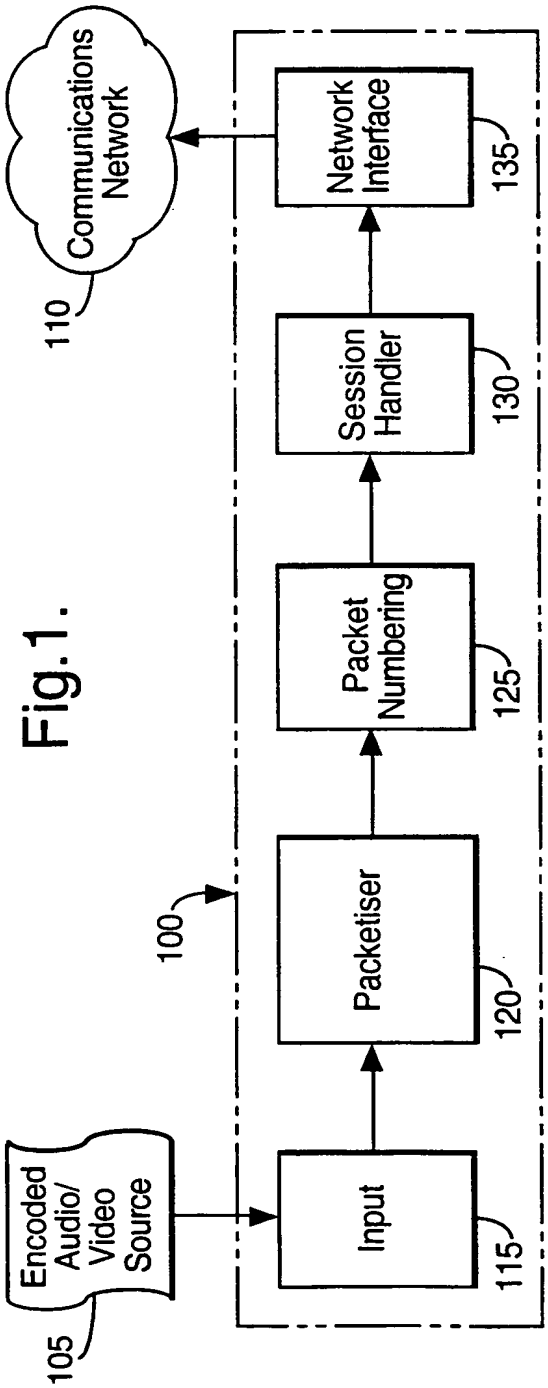

Communications Network
110
Network Interface
135
Session Handler
130
Packet Numbering
125
Packetiser
120
100
Input
115
Encoded Audio/ Video Source
105

Fig.1.

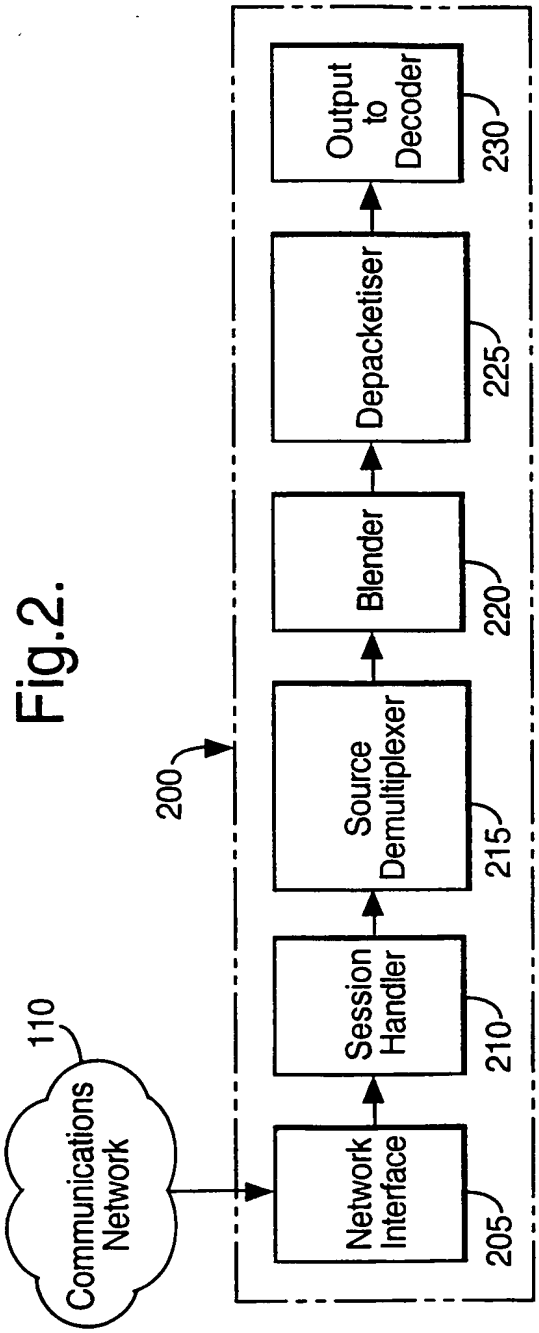

Communications Network
110
200
Network Interface
205
Session Handler
210
Source Demultiplexer
215
Blender
220
Depacketiser
225
Output to Decoder
230

Fig.2.

Fig.3.

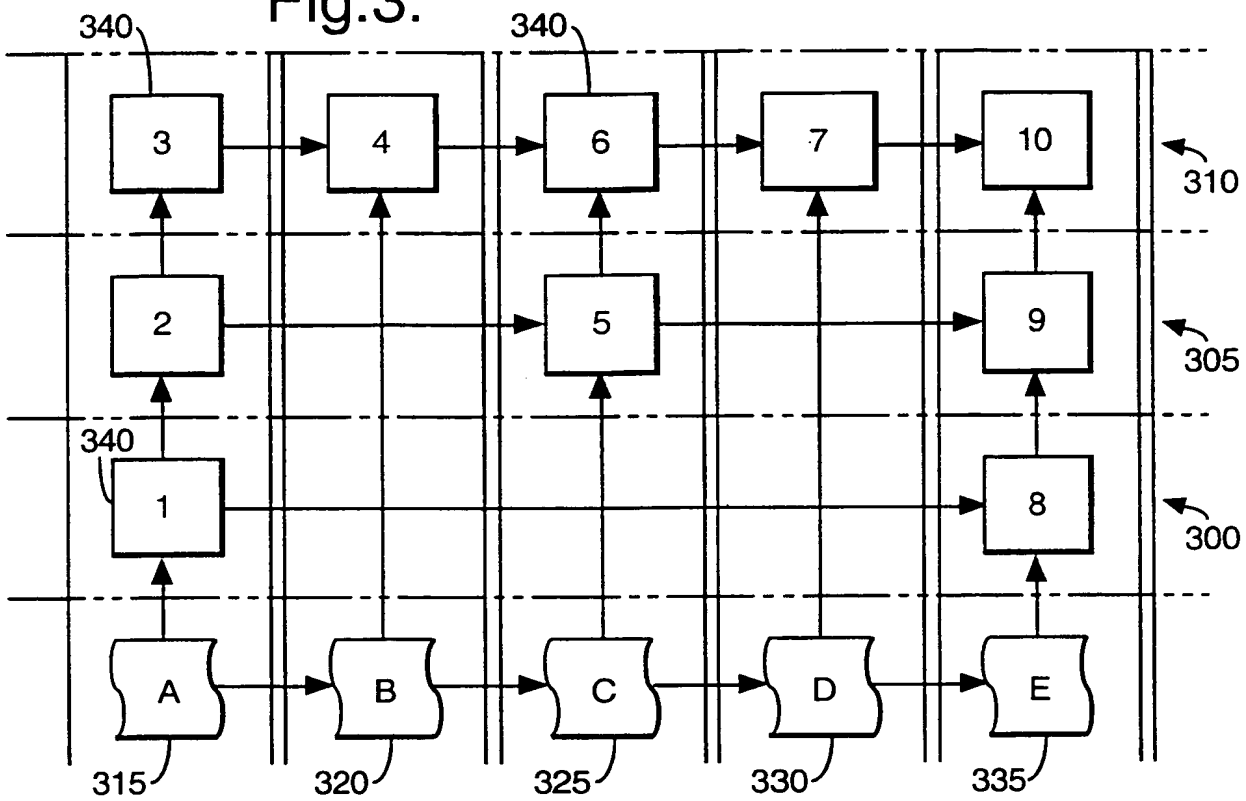

340
340
3
4
6
7
10
310
2
5
9
305
340
1
8
300
A
B
C
D
E
315
320
325
330
335

Fig.4.

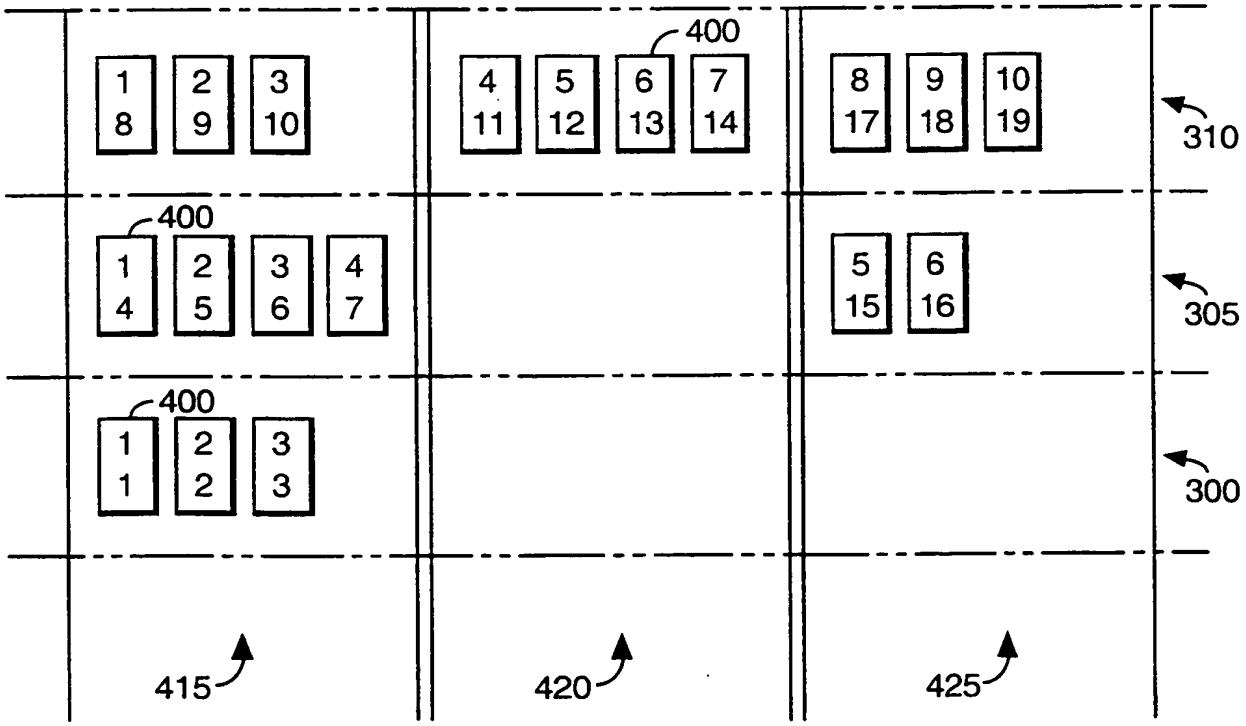

400
1 8
2 9
3 10
4 11
5 12
6 13
7 14
8 17
9 18
10 19
310
400
1 4
2 5
3 6
4 7
5 15
6 16
305
400
1 1
2 2
3 3
300
415
420
425

Fig.5a.

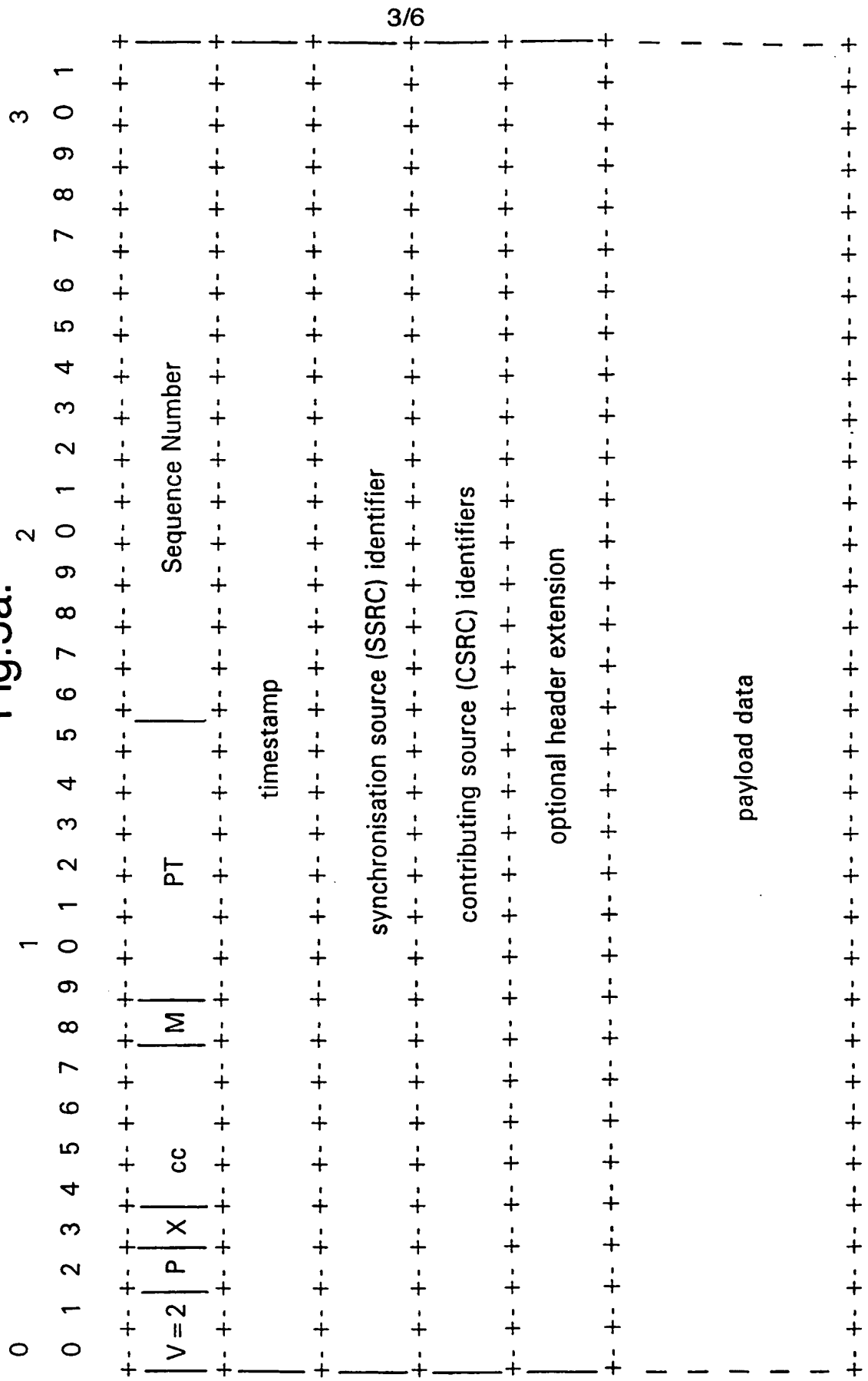

0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
V=2
P
X
CC
M
PT
Sequence Number
timestamp
synchronisation source (SSRC) identifier
contributing source (CSRC) identifiers
optional header extension
payload data

Fig.5b.

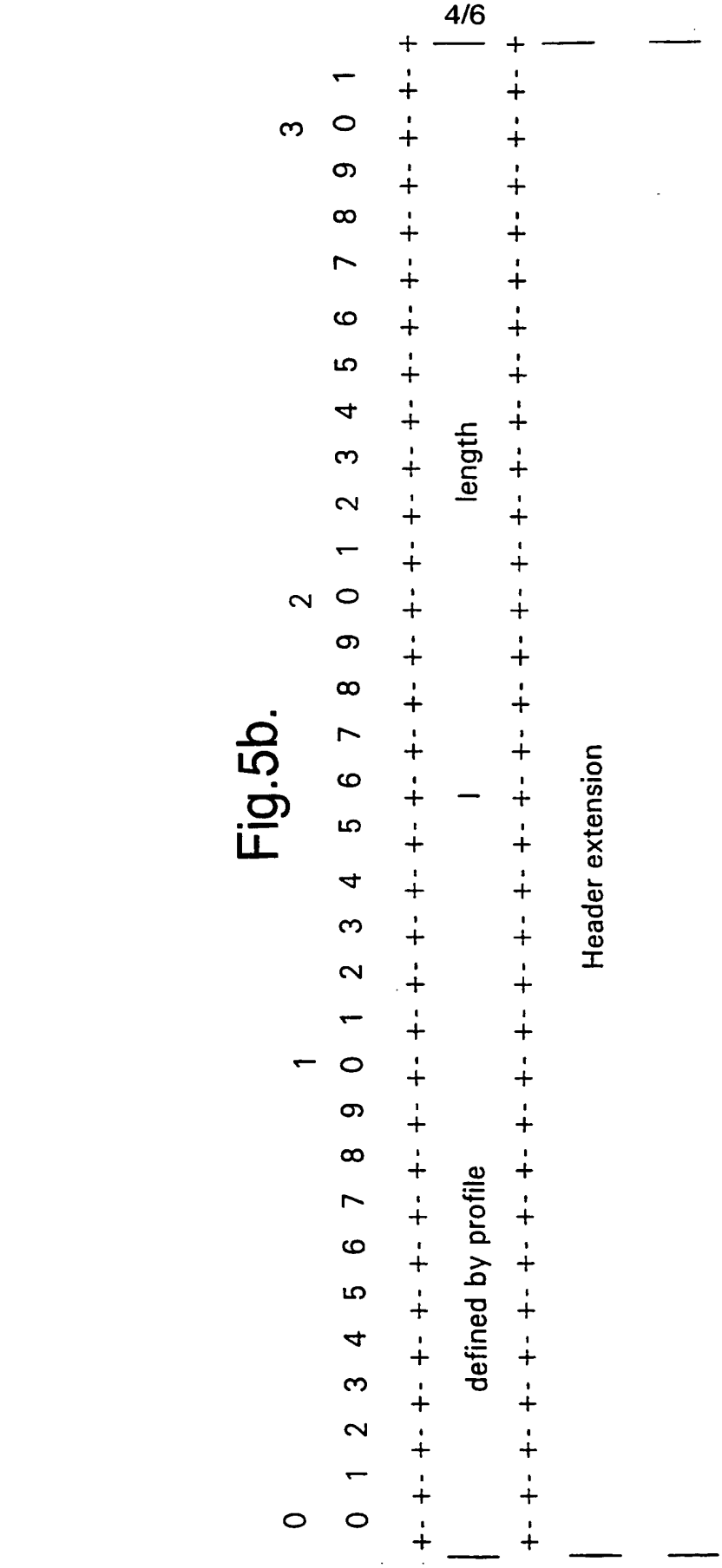

0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
defined by profile
length
Header extension

Fig.6.

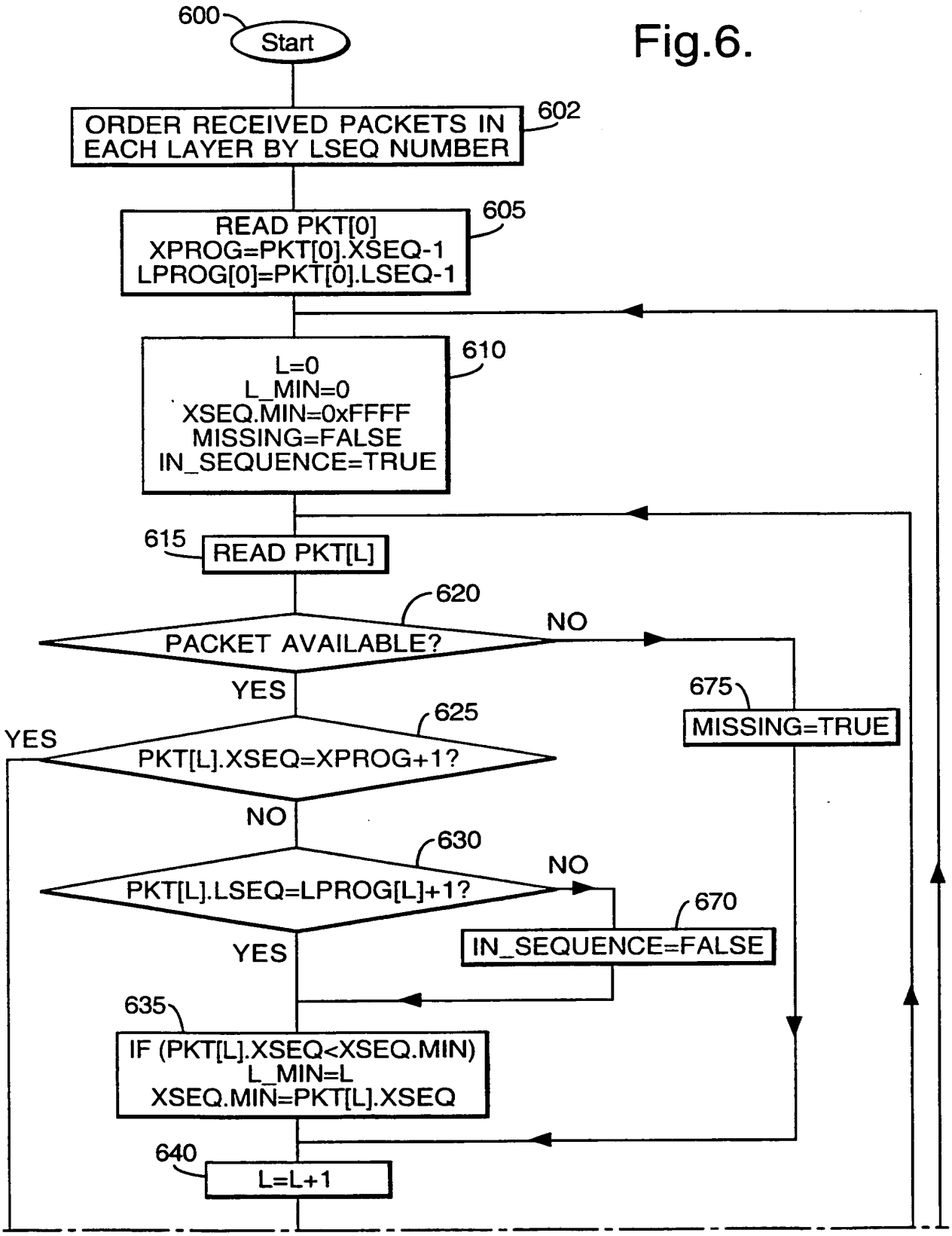
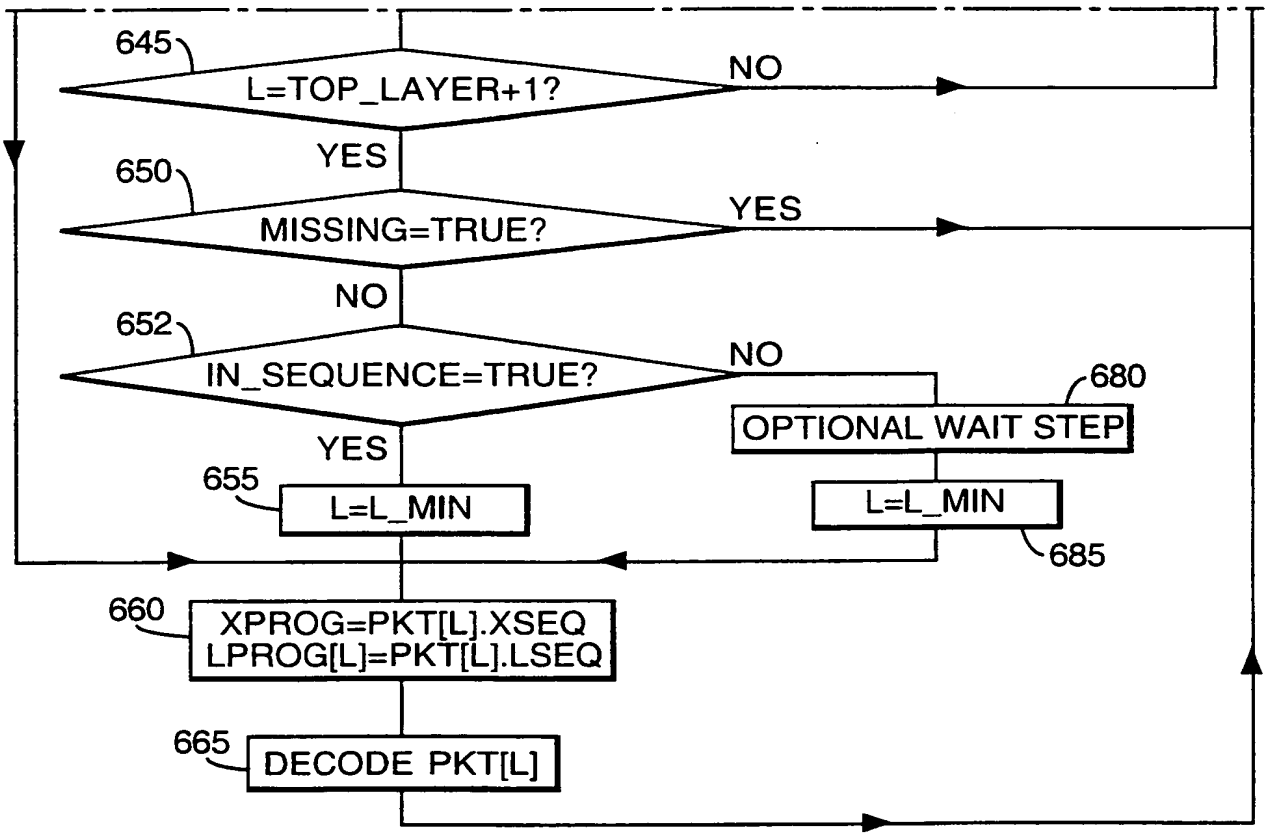

600
Start
ORDER RECEIVED PACKETS IN EACH LAYER BY LSEQ NUMBER
602
READ PKT[0]
XPROG=PKT[0].XSEQ-1
LPROG[0]=PKT[0].LSEQ-1
605
L=0
L_MIN=0
XSEQ.MIN=0xFFFF
MISSING=FALSE
IN_SEQUENCE=TRUE
610
615
READ PKT[L]
620
PACKET AVAILABLE?
NO
YES
675
MISSING=TRUE
625
YES
PKT[L].XSEQ=XPROG+1?
NO
630
NO
PKT[L].LSEQ=LPROG[L]+1?
670
IN_SEQUENCE=FALSE
YES
635
IF (PKT[L].XSEQ<XSEQ.MIN)
L_MIN=L
XSEQ.MIN=PKT[L].XSEQ
640
L=L+1

Fig.6 (Cont).


645
L=TOP_LAYER+1?
NO
YES
650
MISSING=TRUE?
YES
NO
652
IN_SEQUENCE=TRUE?
NO
680
OPTIONAL WAIT STEP
YES
655
L=L_MIN
L=L_MIN
685
660
XPROG=PKT[L].XSEQ
LPROG[L]=PKT[L].LSEQ
665
DECODE PKT[L]

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03416

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 H04L29/06

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | JAU-SHIUNG HUANG ET AL: "MHTP - A MULTIMEDIA HIGH-SPEED TRANSPORT PROTOCOL" COMMUNICATION FOR GLOBAL USERS, ORLANDO, DEC. 6 - 9, 1992, vol. 3, 6 December 1992 (1992-12-06), pages 1364-1368, XP000390432 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS | 1,2,4-8 |
| A | page 1364, left-hand column, line 12 -page 1366, left-hand column, line 36 page 1368, left-hand column, line 3 - line 47 | 3 |

-/—

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 14 February 2000 | 24/02/2000 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016 | RAMIREZ DE AREL.., F |

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03416

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication,where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | DELGROSSI L ET AL: "HEITP - A TRANSPORT PROTOCOL FOR ST-II" COMMUNICATION FOR GLOBAL USERS, ORLANDO, DEC. 6 - 9, 1992, vol. 3, 6 December 1992 (1992-12-06), pages 1369-1373, XP000390433 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS page 1371, left-hand column, line 2 - line 24 | 4,7,8 |
| A | EP 0 725 506 A (IBM) 7 August 1996 (1996-08-07) page 4, line 4 -page 5, line 4 | 1-8 |
| A | FR 2 736 486 A (PY STEPHANE) 10 January 1997 (1997-01-10) page 4, line 31 -page 7, line 24 | 1-8 |

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/03416

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| EP 0725506 A | 07-08-1996 | US 5533021 A | 02-07-1996 |
| | | JP 2898914 B | 02-06-1999 |
| | | JP 8321836 A | 03-12-1996 |
| | | JP 11261600 A | 24-09-1999 |
| | | US 5537408 A | 16-07-1996 |
| | | US 5652749 A | 29-07-1997 |
| FR 2736486 A | 10-01-1997 | NONE | |

able to receive the lowest layer 0 by accessing the appropriate multi-cast address for layer 0. Users who so choose, or who have equipment capability to receive higher layers may access one or more of the corresponding network addresses to enjoy a higher quality of audiovisual service. In this way, disparate client needs may be satisfied by a single broadcast of each layer without unnecessary duplication of data.

Where multi-casting techniques are being used in relation to IP networks, a currently preferred protocol for transporting layers of encoded data frames is the User Datagram Protocol (UDP) as defined in "User Datagram Protocol", Internet RFC 768, J. Postel, August 1980, published on the Internet by the Internet Engineering Task Force (IETF). However, while UDP offers a more rapid procedure for sending messages with a minimum of protocol mechanism, in comparison with the Transmission Control Protocol (TCP) for example, this is achieved at the expense of guaranteed delivery. Data may be lost, perhaps to the extent that a one layer may be lost during conveyance over a network, or at least delayed with respect to other layers. Therefore, besides exercising a choice not to receive a higher layer of encoded data, there are involuntary reasons why a client apparatus may not receive all encoded data broadcast within a session. In both circumstances, problems may arise at a client apparatus in presenting received data to a decoder in the correct order for decoding.

According to a first aspect of the present invention, there is provided a data streaming apparatus, having:

a data input for receiving data frames encoded by a layered encoding algorithm;

packetising means to insert received data frames, so encoded, into one or more predetermined packet structures, the data frames associated with each encoded layer being inserted into a different respective sequence of packets;

packet numbering means to assign a data sequence number to each packet generated by the packetising means, the data sequence number assigned to a packet being indicative of the order of receipt, at the data input, of encoded data inserted within the packet; and

a network interface to transmit, in use, packets so created.

The present invention enables a sequence number to be assigned to each data packet, conveying encoded data, representative of the correct order for

of presentation of encoded frames to a decoder. Any variation in the expected delay between receipt of a first encoded frame from the base layer and the first from the enhancement layer, for example, would not be correctable prior to decoding.

In Internet RFC 1693: "An Extension to TCP: Partial Order Service", November 1994, an extension to TCP is described for transmitting a service profile during connection setup, defining an acceptable order of receipt for transmitted objects. The service profile includes a partial ordering matrix defining an acceptable order for numbered objects, enabling a receiver to order such objects to the extent defined in the profile, even though there may be loss or excessive delay in receiving certain objects. However, the overhead in defining and transmitting service profiles, prior to sending data, increases the complexity of transmitting and receiving apparatus and introduces additional delay.

According to a first aspect of the present invention, there is provided a data streaming apparatus, having:

a data input for receiving data frames encoded by a layered encoding algorithm;

packetising means to insert received data frames, so encoded, into one or more predetermined packet structures, the data frames associated with each encoded layer being inserted into a different respective sequence of packets;

packet numbering means to assign a data sequence number to each packet generated by the packetising means, the data sequence number assigned to a packet being indicative of the order of receipt, at the data input, of encoded data inserted within the packet; and

a network interface to transmit, in use, packets so created.

The present invention enables a sequence number to be assigned to each data packet, conveying encoded data, representative of the correct order for

able to receive the lowest layer 0 by accessing the appropriate multi-cast address for layer 0. Users who so choose, or who have equipment capability to receive higher layers may access one or more of the corresponding network addresses to enjoy a higher quality of audiovisual service. In this way, disparate client needs may be satisfied by a single broadcast of each layer without unnecessary duplication of data.

Where multi-casting techniques are being used in relation to IP networks, a currently preferred protocol for transporting layers of encoded data frames is the User Datagram Protocol (UDP) as defined in "User Datagram Protocol", Internet RFC 768, J. Postel, August 1980, published on the Internet by the Internet Engineering Task Force (IETF). However, while UDP offers a more rapid procedure for sending messages with a minimum of protocol mechanism, in comparison with the Transmission Control Protocol (TCP) for example, this is achieved at the expense of guaranteed delivery. Data may be lost, perhaps to the extent that a one layer may be lost during conveyance over a network, or at least delayed with respect to other layers. Therefore, besides exercising a choice not to receive a higher layer of encoded data, there are involuntary reasons why a client apparatus may not receive all encoded data broadcast within a session. In both circumstances, problems may arise at a client apparatus in presenting received data to a decoder in the correct order for decoding.

In Jau-Shiung Huang et al.:"MHTP – A Multimedia High-Speed Transport Protocol", from GLOBECOM '92, Orlando - Communication for Global Users, Dec 6-9, 1992, Volume 3, 6 December 1992, pages 1364-1368, XP000390432 IEEE, a protocol (MHTP) is described that enables packet sequence numbering and packet ordering to be managed within each of several sub-protocols as may each be used to convey a separate layer of multi-layer encoded data. However, MHTP does not solve the problem of how to present received packets, selected from across several sub-protocol layers, to a decoder in the correct order for decoding.

In "An Efficient Loss-Priority Scheme for MPEG-2 Variable Bit Rate Video for ATM Networks", Wilson, D. and Ghanbari, M., IEEE 1996, Essex University, a technique is described for generating an enhancement layer comprising only B-frames, though relying upon the correct relative timing of the base layer and the enhancement layer being maintained during transmission to ensure correct order